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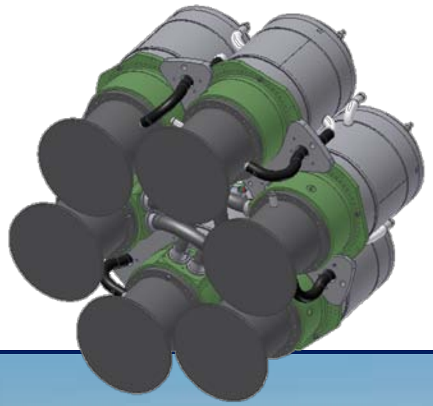

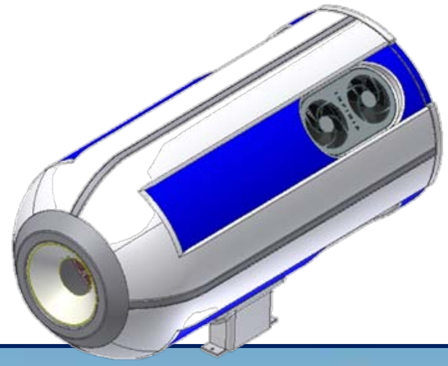

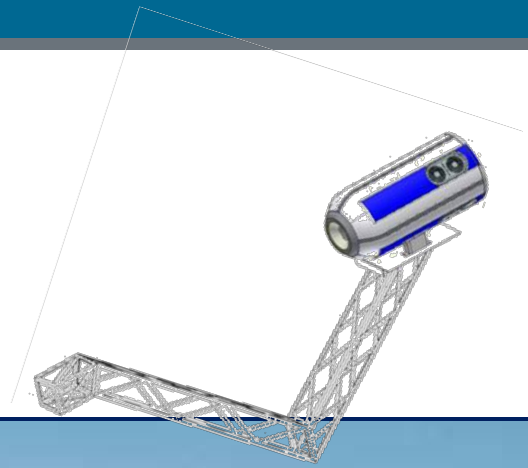

30kW Maintenance Free Stirling Engine for Concentrating Solar Power

CSP Program Team

Songgang Qiu

Infinia Corp

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May 25, 2010

Timeline

- Project Start: March 1, 2008
- Project End: Dec 31, 2011
- Percent Complete: 60% (as of May 1, 2010)

Barriers

- Capacity factors and Levelized Cost of Electricity (LCOE) for dish-Stirling power systems

Budget

- Total Project Funding:
  - Phase 1&2
  - – DOE Share: $1,236,701
  - – Contractor Share: $309,175

Partners

- Project Lead: Infinia Corp.
- Interactions/Collaborations:
  - Sandia National Labs
  - Ricardo

Challenges, Barriers or Problems

- Market Challenges, Barriers or Problems to be Addressed
  - Improving energy density of maintenance free Stirling engines
  - Combining long life, maintenance free free piston Stirling engines with the simplicity of multi-cylinder Stirling engines
  - Reducing Levelized Cost of Electricity (LCOE) of dish-Stirling power generators to 7¢/kWh
- Relevance: Successful demonstration of the 30kW multi-cylinder Stirling Engine
  - Reduces LCOE cost for CSP Stirling engines
  - Improves long term reliability and manufacturability of CSP Stirling engines

Relevance

- Project Objective
  - Perform development work to verify functionality of a 30kW multi-cylinder Stirling engine, and demonstrate that functionality in a laboratory environment, followed by an on sun demo.
- Support to DOE Goals
  - This objective supports DOE goals to increase the use of CSP in the USA, making Stirling engine based CSP more cost competitive.

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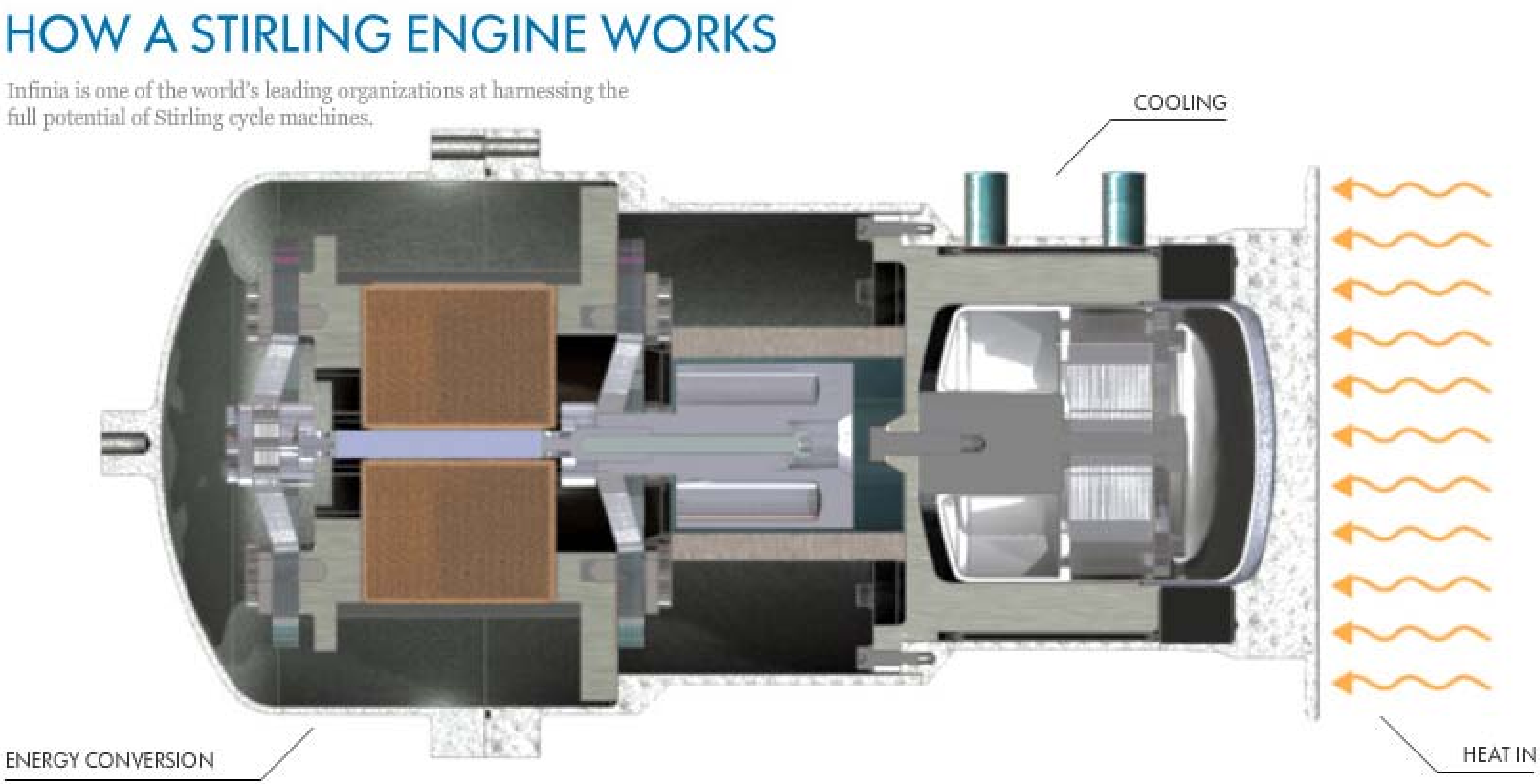
Single Cylinder Free Piston Stirling Engine



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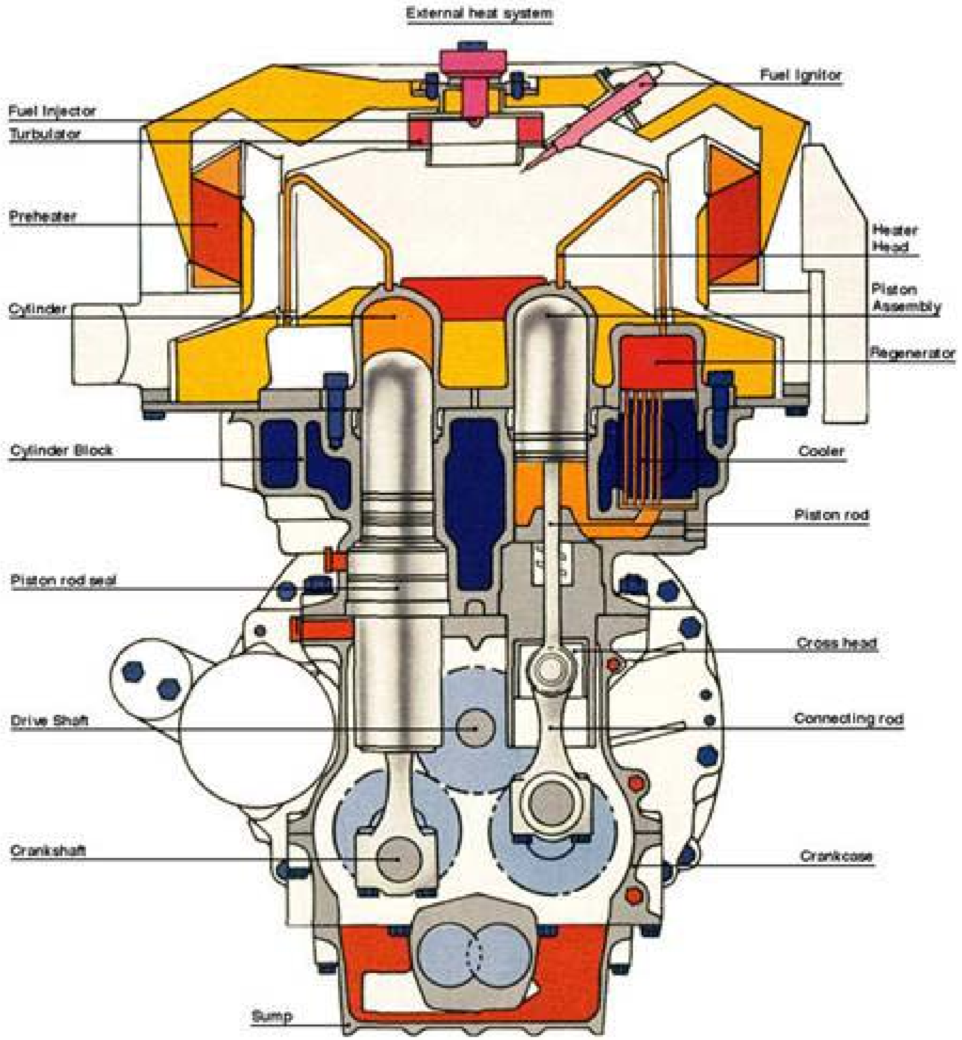
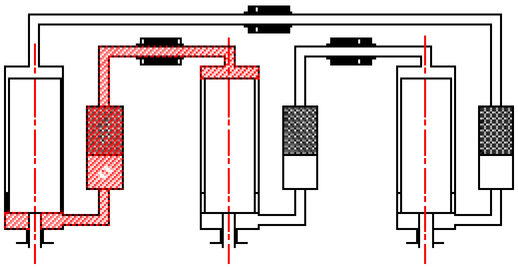
Kinematic Multi-Cylinder Stirling Engine

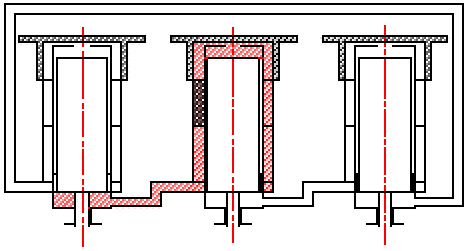


Multi-Cylinder Free Piston Stirling Engine

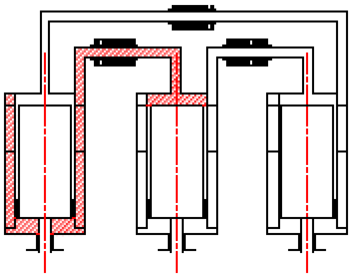
- Three different basic configurations are available.
- Annular construction with an integral hot heat exchanger chosen
- Minimizes engine footprint and complexity
- Leverages Infinia core competency



CANNISTER / EXTERNAL HOT HX



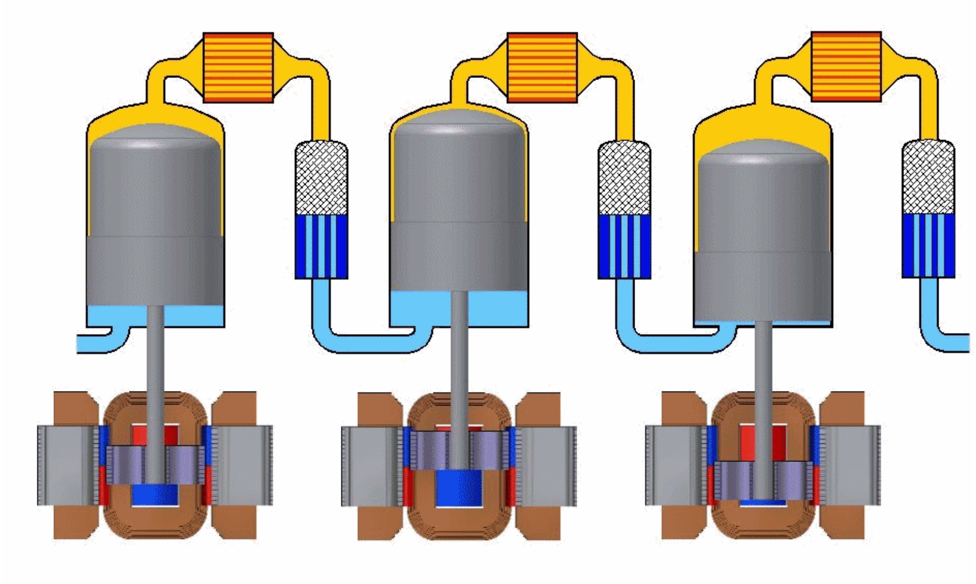
ANNULAR / INTEGRAL HOT HX



ANNULAR / EXTERNAL HOT HX

Multi-Cylinder Free Piston Stirling Engine

- Double acting, free piston design
- No displacer, connecting rods, cams, etc.
- Thermodynamic cycle forces piston phasing (120° for 3 cylinders)



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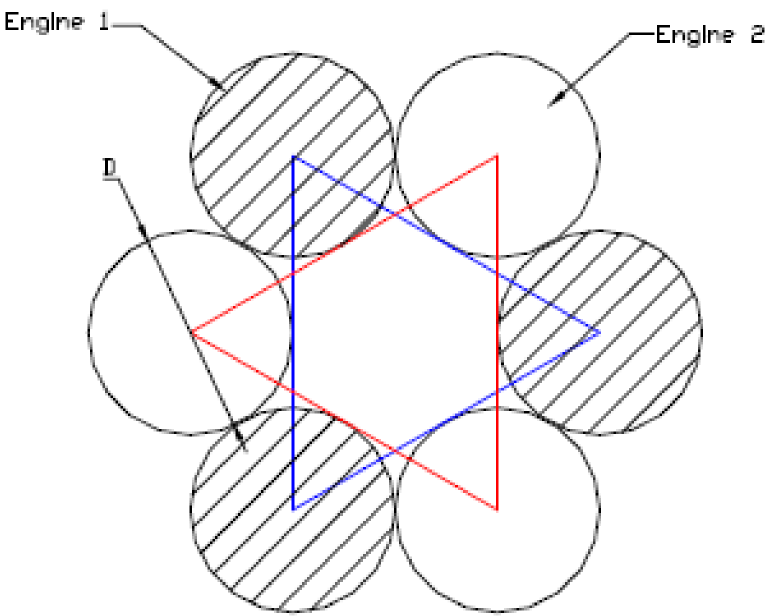
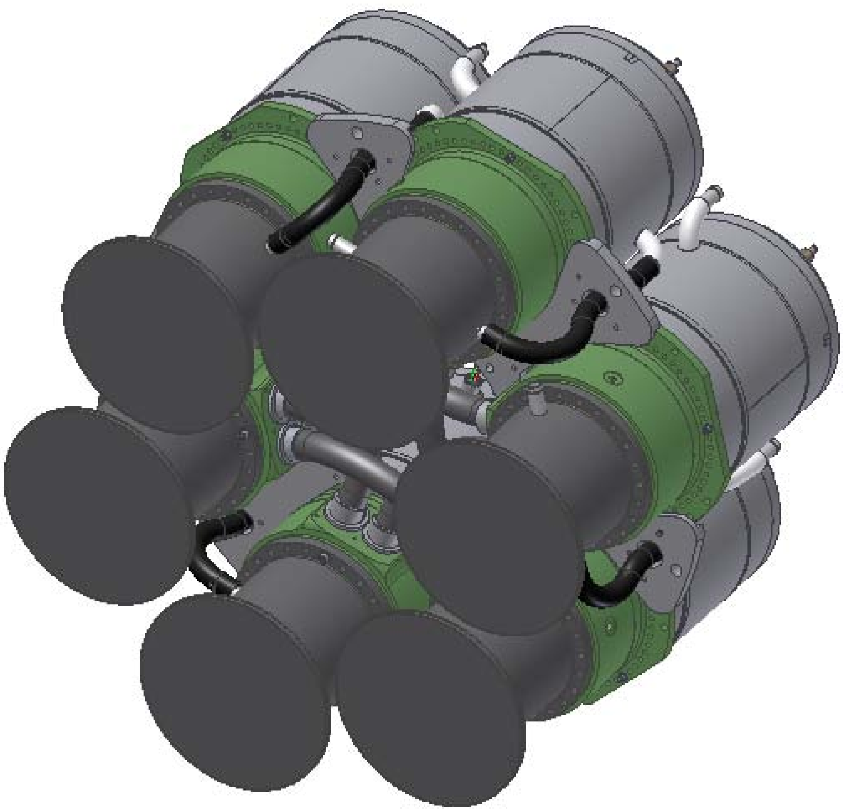
30kW Design

- Engine 1 and 2 are connected as shown
- Simplest configuration to interconnect that produces no net vibration



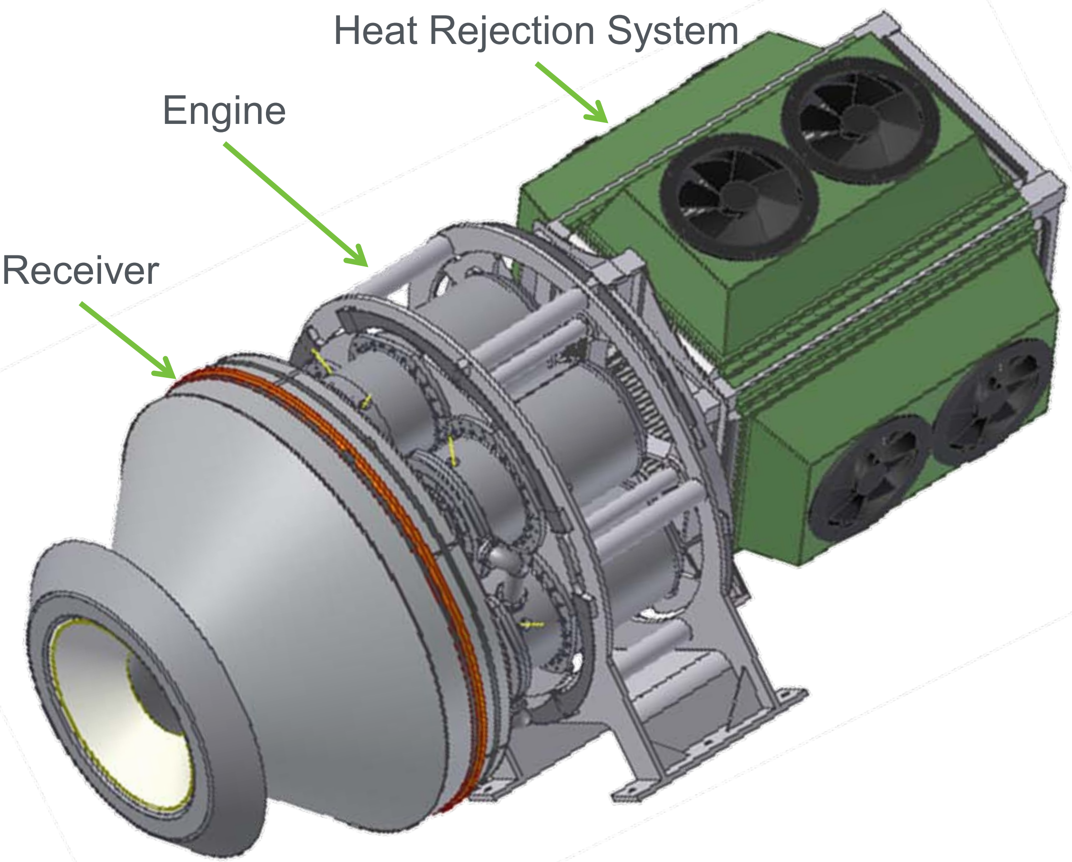
30kW Design

- 6 Interconnected 5kW engine cylinders configured into a pair of 15kW engines
- Relative piston phasing cancels out vibration
- Estimated weight for the prototype, 900kg
- Preliminary production weight estimate of <500kg



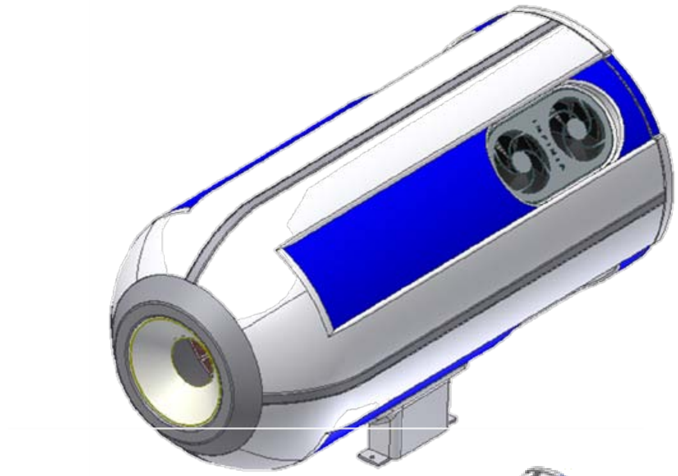
30kW Design

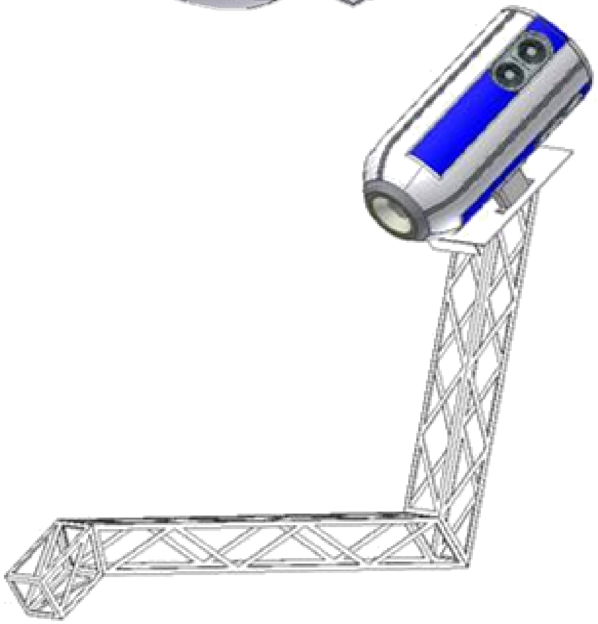
- Heat Drive Core
  - Receiver is at the focal point of the reflecting dish
  - Heat Rejection System
    - Radiators
    - Fans
    - Pumps
  - Provides structural support to all components and boom mount attachment points



30kW Design

- Boom Mounted Heat Drive
  - Asthetically appealing shell over heat drive core
  - Boom mounts to dish





- Project Timeline

		2008												2009												2010							
Phase	Task	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8
1	1-Preliminary Design																																
	2-Engine Integration/Interface design																																
	3-Cost Analysis																																
	4-Management																																
2*	1-Detailed Design																																
	2-Fabricate & Assemble																																
	3-Evaluate Prototype																																
	4-Refine Cost Analysis																																
	5-Management																																
3**		2010												2011												2012							
	1-Produce Field Engine & BOP																																
	2- Install and Test																																
	3- Verify Production Costs																																
	4- Develop Production/Buisness Plan																																
	5- Management																																

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Collaborations

- Infinia Corp. – Lead
- Ricardo – Cost Analysis
- Sandia National Laboratories – Dish for the 30kW and testing support

Summary

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- 30kW Multi-cylinder Stirling Engine
  - Lower complexity and part count than kinematic multi-cylinder Stirling engines
  - Longer life than kinematic multi-cylinder Stirling engines
  - Maintenance free over the life of the engine
- 30kW Program
  - Prototype fabrication is on track
  - Initial demonstration of the laboratory engine: summer 2010
  - On Sun demonstration: Spring/Summer 2011